DOWNHOLE VIBRATION MONITORING & CONTROL SYSTEM
QUARTERLY PROGRESS REPORT #14

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Principal Author:	Martin E. Cobern
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ABSTRACT

The objective of this program is to develop a system to both monitor the vibration of a bottomhole assembly, and to adjust the properties of an active damper in response to these measured vibrations. Phase I of this program, which entailed modeling and design of the necessary subsystems and design, manufacture and test of a full laboratory prototype, was completed on May 31, 2004.

The principal objectives of Phase II were: more extensive laboratory testing, including the evaluation of different feedback algorithms for control of the damper; design and manufacture of a field prototype system; and, testing of the field prototype in drilling laboratories and test wells. Phase II concluded on January 31, 2006.

The month of January was devoted to the final preparations for, and conducting of testing of the DVMCS at TerraTek laboratories in Salt Lake City. This testing was concluded on January 27, 2006. Much of the effort in this period was then devoted to the analysis of the data and the preparation of the Phase II final report. The report was issued after the close of the period.

Work on Phase III of the project began during this quarter. It has consisted of making some modifications in the prototype design to make it more suitable for field testing an more practical for commercial use. This work is continuing.

The redesign effort, coupled with the current extreme lead times quoted by oilfield machine shops for collar components, will delay the deployment of the field prototypes. The precommercial prototypes are being developed in parallel, so the project should be completed per the current schedule.

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Executive Summary

The objective of this program is to develop a system to both monitor the vibration of a bottomhole assembly, and to adjust the properties of an active damper in response to these measured vibrations. Phase I of this program, which entailed modeling and design of the necessary subsystems and design, manufacture and test of a full laboratory prototype, was completed on May 31, 2004.

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Design

Redesign of laboratory prototype
COMPLETE.

Design of feedback system
COMPLETE.

Intermediate prototype design
COMPLETE

Design of field prototype tool
During assembly and test of the intermediate prototype tool, several observations were made that had significant bearing on the design of the field prototype and the eventual commercial tool. These include:

- The internal position monitor (LVDT) did not produce sufficient signal within the collar to control the feedback loop, and it was necessary to rely upon an external sensor during the TerraTek testing. This has necessitated a complete redesign of the LVDT, which is currently underway. Tests with a ¼-scale model were very promising and a full-scale laboratory prototype is currently being assembled.
- Assembly of the laboratory prototype, and its conversion to the drilling lab prototype, demonstrated that the current design was overly complicated and extremely difficult to assemble, and not commercially viable.
- Furthermore, potential commercial partners indicated a strong preference for a system which can be integrated into their existing shock subs. A significant part of the DVMCS (bearings, Belleville springs, *etc*.) is very similar to a shock sub, with the key addition being the active feedback and control system.

Based on these considerations, the use of our existing prototype in the field was not considered practical and began a redesign. The result will be a much improved tool. In particular:

- The hydraulic compensation system was modified so that it uses a single reservoir at the top of the tool. By eliminating the lower reservoir, the bottom end of the tool becomes essentially identical to a standard shock sub. This permits its integration into existing products and will greatly reduce manufacturing costs.
- A reconfiguration of the tool permits greater flexibility in assembly and maintenance. In particular, it will not be necessary to depressurize the MR fluid section to perform routine maintenance.
- The part count has been significantly reduced.

These efforts have taken significantly longer than had been anticipated in our revised schedule, and were not completed during this period. This will cause some delays in the manufacture and deployment of the prototype tool, but the project as a whole should be complete per the current schedule.

As the LVDT design, described above, is taking longer than anticipated, the field prototype will be deployed without it.

Design of precommercial prototype tool

The precommercial prototype design is being produced largely in parallel with that of the field prototype. Its design will be essentially the same, with the addition of the LVDT. Therefore, many of the long lead items can be ordered at the same time, with only those parts affected by the LVDT integration being held until its design is fixed.

Experimental

Retesting of DVMCS prototype

COMPLETE

Preparations for Testing at TerraTek

COMPLETE

Testing at TerraTek Drilling Laboratory

During the week of January 23-27, the intermediate prototype was tested according to the test plan developed in the last quarter.T[1]

Analysis

The preliminary analysis of the results at TerraTek indicated that the DVMCS had several beneficial results, compared to a standard drill collar. The ambient noise levels decreased greatly, indicating reduced vibrations. At certain settings of the damping coefficient, the weight and torque seemed more consistent and the drilling rate increased. The enormous volume of data taken has slowed the detailed analysis, while specific data reduction and smoothing software was written and implemented.

The internal position sensor (LVDT) did not provide adequate signal to drive the feedback circuit, so the feedback algorithms were approximated by manual variations. This has led to the redesign of the sensor described above.

Units

To be consistent with standard oilfield practice, English units have been used in this report. The conversion factors into SI units are given below.

1 ft.	=	0.30480 m
1 g	=	9.82 m/s
1 in.	=	0.02540 m
1 klb.	=	4448.2 N
1 lb.	=	4.4482 N
1 rpm	=	0.01667 Hz
1 psi	=	6984.76 Pa

References

[1] M.E. Cobern, "Downhole Vibration Monitoring & Control System Quarterly Progress Report #13," 17 January 2006 Document 41664R13.